point slightly and judge of the workings of a tiger's mind by its actions, we would see that sunshine, soil, rain and dew, the plants, the fat beeves and even man himself are for the tiger's sole benefit.

Surely if the other sides of zoology call for imagination, acute observation, profound study and cold, logical reasoning for their comprehension, this side demands all these and in addition a philosophic spirit, that flower of the cultivated human mind.

I think what has been said will suffice to show that in zoology there is a factor of true mental culture; and that by it the philosopher, the philanthropist, the man of affairs, is better fitted in his own sphere for work and for leisure. If the student feels that some of the inspiration to this culture has departed, that the structure, function, embryology, classification and economics of animals have been almost all discovered and determined, and may be found in the ponderous volumes and monographs in the great libraries, refer him to Aristotle, Darwin, Dana, Gray or Agassiz, or to any of the devoted men and women who have been and are trying to find out the truth and to follow it, they will say: Be of good cheer, and not faint hearted. Look and listen with *brain* as well as eye and ear, for on every side are thrilling sounds whose music no human ear hath heard, and sights whose exquisite beauty no human eye hath seen.

In closing this address I cannot summarize my belief in the cultivating power of the earnest study of zoology better than by saying that a profound contemplation of the factors in the problem of animal life on the earth will bring out and cultivate the mind. It will show man his true relations to his fellow men and to his lowly fellows, the animals. It will not fill the mind with pride, for ultimate knowledge is as yet unattainable; it will rather give the humility expressed by Job: "Canst thou by searching find out God? canst thou find out the Almighty unto perfection?" or by Newton: "I do not know what I may appear to the world; but to myself I seem to have been only a boy playing on the seashore and diverting myself in finding now and then a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me." And another from one of the foremost physicists of our own day, Sir William Thompson, at the jubilee of his appointment as professor of natural philosophy at the University of Glasgow: "One word characterizes the most strenuous efforts for the advancement of science that I have made perseveringly through 55 years; that word is failure; I know no more of electric and magnetic force, or of the relations between ether, electricity and ponderable matter, or of chemical affinity, than I knew and tried to teach my students of natural philosophy 50 years ago in my first session as professor." Yet there is also the pean, if not of victory, of the consciousness of power that comes to him whose mind has been truly cultured by the disciplines brought before you in this series of addresses and none has a surer right to that consciousness or with a surer voice has expressed it than the zoologist in whose place I stand to-day: "The world of thought and the world of action are one in essence. In both truth is strength, and folly and selfishness are weakness. Say what we may about the limitations of the life of man, they are largely self limitations. Hemmed in is human life by the force of the fates; but the will of man is one of the fates, and can take its place by the side of the rest of them."

SIMON HENRY GAGE.
CORNELL UNIVERSITY.

INSTINCT AND EDUCATION IN BIRDS.

THE discussion, first provoked by the note in SCIENCE of February 14th relative

to the origin of instinct and the inheritance of acquired habitual actions, and the remark of Prof. Wesley Mills (p. 441) that "before drawing conclusions from observations on domestic animals it is well to consider similar facts in connection with their wild congeners," have led me to make a few experiments upon a fledgling of our common kingbird (*Tyrannus tyrannus*), captured July 2d, as it was taking one of its first lessons in flight.

As is well known, the kingbird is exclusively insectivorous and generally captures its prey on the wing, though it does not refuse insects that may lurk in the foliage, and it may occasionally descend to the ground in pursuit of grasshoppers, whose movements have betrayed their whereabouts. Being thus in its activities so different from the omnivorous chick, and belonging, moreover, to the great group of Gymnopædes, or birds, which, naked-born, are fed in the nest, we might expect certain differences from the instincts and habits of the precocious, downy chick. Such differences may throw light upon the questions of comparative psychology though, as the material for purposes of generalization is augmented, they may prove to be variations of no direct suggestive value.

From July 2d to the 11th the bird, almost incessantly calling for food, was kept in the house and fed, from the hand, shreds of meat, moist bread and a few insects. Water was taken from the wet finger, not as a drop from the tip, but finger and all were seized, the subsequent motions of deglutition being the same as though any large morsel were being engulfed. To the present day (July 16th) the bird has utterly refused to accept the pendant drop; nor could it be induced to peck a drop from a leaf or from the surface of any object whatever.

On July 11th I offered the bird a small porcelain dish (such as is used for extract of beef) filled with water. Though hungry and presumably thirsty, no effort was made towards taking the water, but the dish was repeatedly seized with the same eager fluttering that characterized the general reception of any proffered article, edible or not. (It was noted that the tongue during this act was in rapid motion.) While making an unusually awkward lunge at the edge of the dish the bill was accidentally thrust deep into the water, and quickly withdrawn with an unmistakable air of surprise, followed by an effort to *eat* the water held between the mandibles. The jaws snapped; the tongue could be seen shooting back and forth, and the head, first held horizontally, was only slowly tipped backward and then, not in the way of the chick, described as instinctively perfect, but after the retching method of mouthing and swallowing any object not readily responsive to the contractions of deglutition and which must needs have the added assistance of the attraction of gravitation.

Though the porcelain dish was afterwards repeatedly offered from July 11th to the 16th and invariably evoked notes of approval, the bird in securing the liquid always bit the edge and never once dipped the beak beneath the surface, nor drank in the approved method of the chick. The earlier awkward movements, however, were greatly improved through repetition. The substance of the water seemed never to be visually observed, and the empty dish held in the hand evoked the same clamorous approval as when filled with water, and was later recognized even when accidentally met, though a saucer which had not contained food or water evoked no sign of interest.

On the morning of July 12th it was noted that if water was allowed to fall from a height the bird became greatly agitated, opened its mouth and vigorously struck at the descending drops, and several were

swallowed with evident signs of relish. Up to this time, while in my possession, the animal had taken food only when placed by the fingers in the gaping mouth, and had made no effort to pick, selectively, the food from between the fingers; nor had it even changed its position on the approach of food, but had remained in one place, fluttering and incessantly calling until the food was brought to it. On the morning of the following day falling drops were again struck at and seized, though the bird did not relish the accompanying wetting. At noon the drops were again seized and swallowed. Signs of disapproval of the wetting were shown on the morning of the 14th, and on the morning of the 15th the bird avoided falling water and was content with biting the edge of the dish.

From the above observations I am inclined to agree with Prof. Mills that the nature of eating and of drinking are not radically different and, as the physical condition of substances may pass imperceptibly from solid to liquid, so the physiological processes are practically the same whether the food is solid, pultaceous or liquid; though I should not attempt to compare too closely the relative perfection of the two processes (p. 356). I do not, moreover, feel that the first act of drinking is in its totality necessarily instinctive (p. 355). In other words, 'when a chick first drinks on its beak being put into water' the act may be considered as, very largely, a result of self-teaching.

The phenomena of eating and of drinking have not, in the discussion, been definitely defined, and there has been some lack of discrimination in the use of the word 'swallow.' The beak, moreover, is mentioned by Prof. Mills and Lloyd Morgan, as the organ the stimulation of which produces the act of drinking, though Prof. Baldwin attributes the action to the stimulation of the sense of taste.

It seems to the writer that the entire process of eating and drinking should be divided into three parts, viz., (1) seizure, (2) mouthing or mulling and (3) deglutition. It is only in the first of these that the term instinct in the sense of inherited habit is necessarily used. Baldwin, Mills and Lloyd Morgan are practically agreed that the young chick seizes instinctively on being stimulated by some small, striking object at a suitable distance. This object may be nutritious or it may be a feather, a pencil or a nail head, a drop of water or a drop of ink. The mechanism is ready and the stimulus properly applied produces the instinctive mechanical, or, as Lloyd Morgan would prefer, organic action.

The object now held between the mandibles and mulled is subject to the examination, strikingly evident in the kingbird, of the tongue, an organ at the same time tactile, gustatory and locomotory. It stands at the portal which leads from instinctive to reflex action and is at once the inspector, reporter and director of that which first stimulated the eye and now, through a motor response, has been placed where it may stimulate other special sense organs: taste, touch and probably smell. It is here that instinctive action becomes guided by individual control, and intelligence begins to act through experience.

The mouth-parts of the young kingbird are large and the deliberate movements are easily observed. I feel therefore that this second and essential portion of the process of eating and drinking in the small-mouthed chick may have been neglected or overlooked. Moreover, the process of the perfecting of the action of eating and drinking through repetition and the guidance of the intelligence is, in the kingbird, comparatively slow and inclines one on the grounds of comparative psychology, to the belief that the complex act of the chick may be only *apparently* perfect from the first, the

successive processes of coordination being in the chick much more quickly perfected.

The process in the kingbird as above detailed gives at least an opportunity for the more definite limitations of those actions which Prof. Baldwin has, perhaps unfortunately, called half-congenital.

The action of the callow bird in deglutition is probably performed as a reflex on the stimulation of the presence of food in the pharynx. Small fragments upon the beak and in the anterior portion of the mouth are not perceived and do not quiet the almost irritating clamor of the gaping young. The enormous size of the mouth, the thickened 'lips' and the bright colored concentric markings of the oral walls make a target, the sensitive center of which (the opening of the œsophagus) only a most awkward parent could fail to hit. We might argue that the young nestling has not, at first, a definite sense of taste, and actual experiment on the kingbird shows that most unsavory morsels when placed in the mouth are swallowed, though not without subsequent signs of surprise, if not of disgust. It is not, then, difficult to perceive that the young bird while still within the nest acquires, as a result of the selective activity of the parent, a taste for certain food. The discriminative exercise of the sense of taste is thus a result of direct tuition. The young cow-bird whose foster parent has been a vireo will doubtless acquire a relish for food very different from that enjoyed by, perchance its own brother, but, the ward of a graminivorous finch.

It may be objected that the orphan chick selecting food without the discriminative direction of a parent, is not a parallel case with the young kingbird: The bird in my poseession was so tame that when it reached an age comparable with the newly-hatched chick, I could take it into the fields and observe it as it foraged, chick-fashion, for itself. I think that I saw it capture its first insect; I, at least, observed its ability as an insect catcher develop from almost *nil* to expertness. During these excursions observations were made and data collected for the determination of the following questions: Is there an inherited discrimination in favor of the capture of certain edible insects in preference to others? If unsavory insects are unwittingly taken into the mouth are they swallowed? If ejected from the mouth are there signs of disgust? When unsavory examples are met a second time are they avoided?

To the first question I can reply that, at first, all insects were indiscriminately seized. A vile-smelling Hemipteron was as tempting as a luscious grasshopper or cricket. Distinctly unsavory insects (*Tetraopes*, *Coccinella*) were not touched a second time, except with the greatest caution; though species which were only moderately distasteful (*Lema*) might be taken and devoured, but *without* relish. In one case a large brown ant, the first found, was seized, mulled and vigorously ejected. The next day the bird was taken to the same tree and, on perceiving a second ant of the same species, eyed it closely and deliberately, and then shook its head and vigorously wiped its beak with unmistakable signs of recollection. I mention this particular case, though it is not the only one, to illustrate how quickly the bird was self-taught, for the ant was only one of a dozen different species of insects which were met, and it was so instantly seized that a prolonged visual image was not gained. I might add that the kingbird subsequently refused even to try the edible qualities of a large black ant of a different species, though the bird watched the insect's movements with much interest. Profiting by mistakes it soon learned to examine critically all strange food before the tongue should force the contents of the mouth on towards the pharynx.

Can we not then conclude that the forcing of acceptable food and drink into the pharynx is not 'instinctive,' but is the result of a series of satisfactory discoveries of the young bird which lead up to the placing of the food where it will bring about the stimulation of the reflex center of the gullet and the accomplishment of the final act of swallowing—a series which is intelligently adopted by the bird and improved by practice.

It is perhaps well, before closing, to revert to the peculiar habit of the bird in snapping at falling drops. From the first, the attention was markedly attracted by flying insects and any small objects in motion seemed to have a peculiar charm. From this fact I am inclined to think that the seizing of drops was no more than the striking at moving objects, though it is possible that the adult habitually takes water on the wing by seizing falling drops of dew or rain. H. C. BUMPUS.

A NORTHERN MICHIGAN BASELEVEL.

KEWEENAW POINT and its southwestern extension in northern Michigan is composed of rocks of Keweenawan and Cambrian ages, and exhibits three chief topographic features. Beginning at the south is a broad area of the so-called Eastern or Potsdam sandstone. This is in a horizontal position, and rests unconformably upon the rocks to the north and south. North of this area is the main trap range of the Keweenawan, which consists largely of basic lava flows, but with lesser quantities of acidic lavas. Interstratified with the lavas are numerous layers of sandstone and conglomerate. The majority of these are thin, but in the upper parts of the series some of the conglomerates are of considerable thickness. The breadth of the main trap range varies from about 4 miles to nearly 10 miles. In a general way the traps and detritals strike northeast and southwest, and dip to the northwest at angles varying from 25° to 55°. At the southwestern part of the area considered, a wing of the trap range swings to the north as the result of a fold. This area is known as the Porcupine mountains. The distance from the southwest part of the Porcupine mountains to the end of Keweenaw Point is about 120 miles. To the northwest, overlying conformably the main trap range, is the upper division of the Keweenaw series, which consists wholly of conglomerates and sandstones. The dips on its southeastern border average about 25°, but they become less and less toward Lake Superior and at the shore they do not average more than 8° or 10°.

For a full description of the Keweenaw series see the Copper-bearing Rocks of Lake Superior, by Roland D. Irving, Monograph V., United States Geological Survey, and in connection with the present description see the maps of plates I., XVII., and XIX.

A recent visit to this area convinced me that this district had been almost completely baseleveled. The two most advantageous points found by me from which this baseleveled area may be seen are, first, the top of the hill occupied by a church in the village of Rockland, and, second, the top of the rockhouse of the Quincy mine, occupying the highest ground above Hancock. From the Rockland point, looking to the northeast the main trap range appears to be an almost level plain. To the southwest the plain is nearly as level, but the Porcupine mountains rise considerably above this plain. The explanation of this monadnock is simple; the core of the Porcupine mountains is hard quartz-porphyry and felsite, rocks more resistant than the interstratified traps and detrital rocks of the main trap range. From the Quincy rockhouse on a clear day the eye sweeps from the Porcupine mountains on the southwest to the end of Keweenaw Point, to the northeast, that is, over the entire 120